DIGITAL COMPUTER NEWSLETTER

The purpose of this newsletter is to provide a medium for the interchange among interested persons of information concerning recent developments in various digital computer projects. Distribution is limited to government agencies, contractors, and contributors.

OFFICE OF NAVAL RESEARCH · MATHEMATICAL SCIENCES DIVISION

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Editorial Policy Notices

EDITORIAL

The Digital Computer Newsletter, although a Department of the Navy publication, is not restricted to the publication of Navy-originated material. The Office of Naval Research welcomes contributions to the Newsletter from any source. The Newsletter is subjected to certain limitations in size which prevent publisting all the material received. Contributed items which are not printed are kept on file and are made available to interested personnel within the Government.

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CONTRIBUTIONS

The Office of Naval Research welcomes contributions to the Newsletter from any source. Your contributions will provide assistance in improving the contents of the publication, thereby making it an even better medium for the exchange of information between government laboratories, academic institutions, and industry. It is hoped that the readers will continue to participate in transmitting technical material and suggestions to the editor for future issues. Material for specific issues must be received by the editor at least three months in advance. It is often impossibl. for the editor, because of limited time and personnel, to acknowledge individually all material received.

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The Newsletter is distributed, without 'harge, to interested military and government agencies, to contractors for the Federal Government, and to contributors of material for publication.

Requests to receive the Newsletter regularly should be submitted to the editor. Contractors of the Federal Government should reference applicable contracts in their requests.

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Computing Centers

Navy Inventory Control

U. S. Navy Ships Parts Control Center
Mechanicsburg, Pennsylvania

In December 1966, the United States Navy Ships Parts Control Center (SPCC), located in Mechanicsburg, Pa., added an IBM System/360 Model 65 to its $13.5 million computer installation. This installation consists of two UNIVAC 490's, two Burroughs 283's, two IBM 1401's, three UNIVAC 1004's, and one IBM System 360, Model 30.

This computer is assisting SPCC in world-wide management of its 300,000 line items valued at over $3 billion and ranging from ships and ordnance parts to ammunition and guided missiles needed to support today's modern Navy and sophisticated weapons systems. In addition, the IBM computer is providing SPCC with much needed computer capacity and flexibility, to meet data processing services requested by other commands located within the Naval Supply Depot. Much of this is being done with little re-programming, since the IBM System/360 will be compatible, via an emulator, with one of the Center's other computer systems--an IBM 7080.

Installation of the System/360

Computing Center
University of Kentucky
Lexington, Kentucky 40506

The University of Kentucky has ordered an IBM System/360 Model 50 which is approximately two to three times as powerful as the present IBM 7040. The 360 will be located in the old post office area and will be installed when the space is renovated. Delivery and installation are dependent upon the speed of renovation.

The components of the first stage delivery will include the 360 processor and storage (265K), four 2311 disk units, five magnetic tape units, a high speed card read-punch (1000/300), and two teleprocessing typewriter terminals. The disk units will allow the application of new techniques in direct access storage methods, and the teleprocessing terminals will permit experimentation with the use of a computer from remote locations.

The IBM 7040 computer will remain at the University during stage I and will be removed at the beginning of stage II, approximately 4 months after initial delivery. The IBM 1410 computer will remain until approximately the summer of 1968. Stage II equipment includes a second printer, two additional disk units, a data cell storage unit, two cathode ray display units, and a high speed computing interface (2701). The data cell will allow up to 400 million characters of information to be quickly accessible to the computer. The cathode ray display units permit rapid retrieval of "pages" of information on a TV type tube, and the 2701 interface makes possible the linking together of the central system with satellite computers over telephone lines.

IBM plans to provide elaborate programming support which also will be delivered in stages. Initial support will include a rather expanded FORTRAN IV compiler, the new general purpose language called PL/1, an expanded linear programming package, an extended general purpose system simulator, and an improved PERT network analysis system. Mid- or late-1967 releases currently scheduled include a multiprogramming operating system, a continuous system modeling program, a generalized information system which will aid primarily in the administrative data processing function, and an ALGOL compiler.

Computers and Centers, Overseas

Large Norwegian Computer System to United States Shipyard

Central Institute for Industrial Research
Oslo 3, Norway

The Autokon System is now in operation on a license basis at the General Dynamics Corporation, Quincy Division, Mass., U.S.A. The System was developed by the Central Institute for Industrial Research, Norway, in close cooperation with the Norwegian shipyards, A/S Akers mek. Verksted and A/S Bergens Mekaniske Verksteder.

The Autokon System encompasses computer-aided design of ships' hulls and their individual parts, and has as its output paper tape for the automatic production of engineering drawings for the control of N/C flame cutting machines. One of the main features of the system is the Autokon Language, designed to be used by ordinary shipyard personnel with no special knowledge of computers. The possibilities of the System have already been clearly demonstrated at several European shipyards and have shown its economic efficiency. With its 1100 pages of documentation and 100,000 computer instructions, this software system is believed to be the largest delivery of its kind ever made from Europe to the United States.

Computing Department Developments

The University of Glasgow
Glasgow W.2, Scotland

The KDF 9 has now been considerably increased in size and is a multi-programming machine capable of working on four programmes at a time with 32K words of 48 bits and core store, 9 magnetic tape units, a 4 million character disk, line printers, paper tape readers and punches, card reader and punch, and graph plotter. The Department will also extend this, in the not too distant future, by attaching a PDP 8 Computer to which is multi-plexed 32 on-line teletypes and a graphical display and light pen.

Scheduled for completion in the spring of 1967 was a multi-access computing project, with the attachment of two on-line teletypes. This project was extended to October 1967 to provide 15 such teletypes for undergraduate use, and then when the PDP 8 arrives, to provide a service throughout the University. This project is known as the GOLD (Glasgow On-Line Desk) project. Also developed were faster multi-access facilities that permitted the paper-tape-reader and light-pen operators' consoles to be located in distant departments.

Multi-Access Mini-Mac System

Elliott-Automation Computers Ltd.
Borehamwood, Herts, England

The Experimental Programming Unit of the University of Edinburgh is carrying out important research into multiaccess computer working. This work, which includes the development of a library of conversational statistical programs is financed by the Medical Research Council. Elliott-Automation Computers, Ltd. are also engaged in an intensive research program in this field following a grant by the Advanced Computer Techniques Project of the Ministry of Technology.

Multi-access techniques are vitally important since they enable computer facilities to be extended to a wider range of users and enable more efficient use to be made of both computing and programmers time. Basically this is achieved by providing remote operating consoles for separate computer users who are able to use the computer simultaneously. Each user can input information and instructions using his local teleprinter, which can also display results and other messages. Although, in fact, the various

users are sharing access to the computer, to each individual user it appears that he has the entire system to himself.

When a program is being typed in at the remote console the information is first placed in a buffer store. The user presses a key when the data or message has been typed, and the message is read into the central store within the space of a few milliseconds, causing minimum effect on the central processor.

Elliott System

The Elliott 4100 multi-access system is designed to operate with a 4130 configuration similar to that shown in Fig. 1 (see also DCN, Oct. 1966).

The buffer store is provided in the form of a magnetic disc unit. The magnetic disc unit is similarly used to buffer output messages destined for the multi-access consoles and to receive output for other slow peripherals. Erratic demand on these peripherals is thus avoided and they are able to operate at full speed.

In addition to serving as an input buffer, the remote user's disc store can also be used as a backing store for dynamic program over-laying and data storage, thus reducing the area of central core store required by each user.

The magnetic tapes, in addition to their normal backing role, are used within the multi-access system for the dumping of users' discs as a protection against system failure. The packed transfer units enable autonomous transfers to take place between discs or magnetic tapes and core store without using the central processor, leaving this to continue its computing uninterrupted.

While the computer is operating, each users' area of central core store is fully protected from access by any other user. To each individual user the 4130 looks like a 4120 system.

Hardware

Several features of the 4130 hardware are specially designed to facilitate multi-access working.

There are three modes of operation:

1. Executive mode. This mode is reserved for the program scheduling executive.

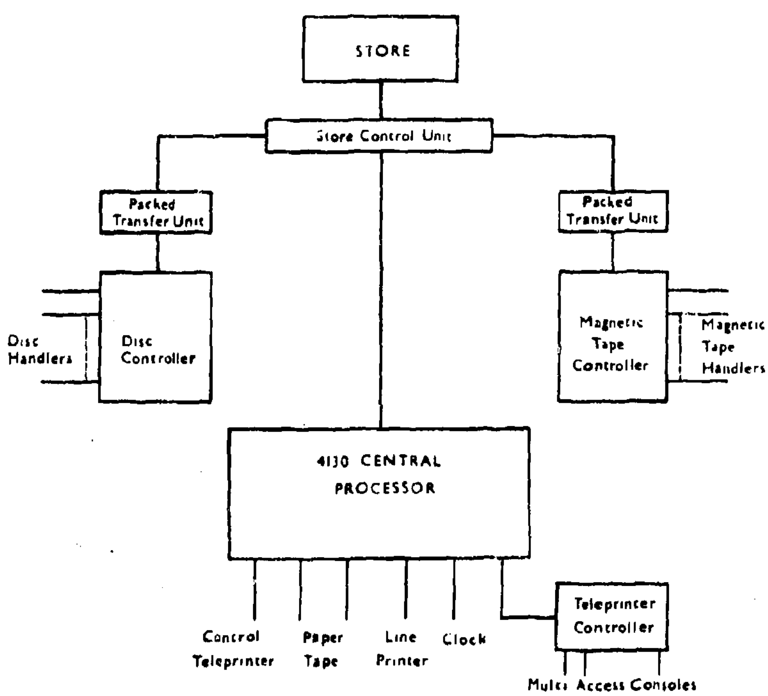

Fig. 1 - Multi-Access Mini-Mac System

2. Protected mode. Users' programs run in the protected mode. Users request an area of store when logging in to the system and during their run this area is protected from interference by any other program.

3. Common mode. The hardware of the 4130 enables the same program to be used simultaneously by a number of multi-access users without it being necessary for each user to have a copy of the program in his area of store.

The inclusion of these special hardware facilities have made it possible for Elliott-Automation to develop multi-access techniques on a relatively small computer.

Edinburgh System

The system which is being developed by the Experimental Programming Unit at the University of Edinburgh is known as the 4100 Mini-Mac system. This is a simple multi-access system designed to operate with an NCR-Elliott 4120 computer with 24K store, control typewriter, paper tape input/output, lineprinter, four disc handlers and four teletype channels to which four remote teleprinter consoles can be attached. Three of these consoles will be available to remote users; the fourth is used for system logging and system evaluation purposes.

The main difference between this system and the 4130 system previously described is that users' programs are switched to and from the magnetic discs, with only one user occupying the main computer store at any one time. On the 4130, with a larger store and hardware protection, it is possible to keep all users' core areas together in store.

Closer Contact

With conventional operating procedures the number of people who could be given direct access to the computer must be limited for practical reasons. Using multi-access techniques, however, a far wider range of users can be brought into direct contact with the computer. Experience has shown that this method of working is far more effective than the indirect passing of computer programs through system operators. The user is brought into closer contact with the work being carried out, a factor which can often change the character of the work involved. For example, in simulation the user is in more immediate contact with the simulated system and for this reason is likely to obtain a much better understanding of it.

Similar benefits apply to program development. The scientist or engineer or other non-computer specialist can develop their own programs, examining many possibilities, making changes which appear necessary as a result of preliminary tests. This is particularly important for students who tend to learn more readily when made immediately aware of mistakes as they are made.

S-Five Computer

*G.E.C. Computers and Automation Ltd
London W.1, England*

G.E.C. Computers and Automation have announced the S-FIVE computer system to fill the middle position in the S-Range series. The S-Range now comprises models S-TWO, S-FIVE, and S-SEVEN (see DCN, April 1967) ranging in price from £10,000 to about £250,000. S-FIVE is fully compatible with the larger S-SEVEN and is both data and input/output compatible with S-TWO. The G.E.C. S-FIVE is especially designed for scientific, general purpose and real-time systems control applications requiring high speed, multiple input/output interactions. Thus S-FIVE can simultaneously perform general purpose computing, handle multiple real-time control functions and process a number of concurrent peripheral input/output operations.

In common with the other S-Range computers, S-FIVE makes extensive use of integrated circuits in a third generation design and also shares the same range of peripheral devices. S-FIVE software, which was developed and tested on the S-SEVEN, includes two operating monitors, three levels of Fortran IV, two assemblers, and a set of utility and diagnostic programs.

Memory cycle time of the S-FIVE is 850 nanoseconds, which is reduced to 600 nanoseconds when overlapping of memory units occurs. Memory size ranges from 4,096 words of 32 bits to 131,072 words. Like the larger S-SEVEN all of memory is addressed directly or indirectly and can be altered in bytes, half-words, words, or doublewords.

Up to eight input/output processors, each with capacity for 32 I/O channels, can be provided with S-FIVE. The computer is delivered

standard with eight input/output channels and 16 general purpose registers, which can be expanded to as many as 256 registers. Up to 224 priority interrupt levels are available.

In addition to computers and software packages, the S-Range includes a full selection of peripheral equipment, including Rapid Access Data Files, low and high-speed magnetic tape drives, keyboard/CRT display units, card equipment printers and paper tape input/output devices. Off-the-shelf system interface units and a full line of analogue conversion instruments permit S-Range computers to be easily interfaced into larger systems.

A basic S-FIVE with 4,096 words of core storage and keyboard/printer costs £40,000, ranging up to about £175,000 for a large system.

G.E.C. S-FIVE SPECIFICATIONS

Memory Capacity:	524,288 bytes (4,096 to 131,072 words)
Memory Cycle Time:	850 nanoseconds; 600 nanoseconds*
Word Size:	32 bits (four 8-bit bytes) plus parity
Registers:	16 - expandible to 256
Major Instructions:	93
Instruction Execution Speeds† (Microseconds):	Load word 2.4 Add 2.4 Multiply 9.5 Divide 15.4
Maximum Number of External Priority Interrupts:	224
Special Features:	Overlapping, Interleaving, Multiple Register Blocks, Memory Protect, Real-Time Clocks, Input/Output Processors, Asynchronous Operation, Monolithic Integrated Circuits
Maximum Number of Input/Output Devices:	656
Maximum Input/Output:	132 million bits per second
Programming Systems:	FORTRAN IV, Assembler, Meta-Assembler, Control Monitor, Batch Monitor, Library
Peripheral Equipment:	Keyboard printer, paper tape reader and punch, card readers and punches, rapid access discs, 7 and 9 channel magnetic tape systems, 600 and 1,000 line-per-minute printers, visual display units and communications interface equipment
Cost of Typical Configuration:	£100,000
Delivery:	1968

*Effective cycle time when overlapping occurs.
†Speeds include indexing.

I.C.T. 1900 Control and Simulation Programming

International Computers and Tabulators Limited
Putney SW15, England

Two new programming languages are available to users of I.C.T. 1900 Series computers. Known as C.S.L. and Simon, these languages have been developed especially to aid in the simulation (or control) by computer of a wide range of applications in operational research. They enable the programmer to express the structure of real-time control systems, or that of a simulation model, in the same way he would describe the real process. A third language known as Mobula is being developed.

The components of a model are called entities, and each entity is a member of a class of similar entities. The new languages provide facilities for conveniently recording the states of the entities in sets. A set is an ordered list of entities and normally represents a particular property common to all the entities in the set.

A simulation language provides the programmer with an automatic time advancement system. In both C.S.L. and Simon time is

advanced in discrete steps only to the times when changes in the model take place. A random number generator is provided in each case together with facilities for accumulating results in histograms and sampling from statistical distributions.

1900 C.S.L.

1900 C.S.L. is an extension of the original version of C.S.L.1 developed jointly by IBM (United Kingdom), Ltd. and Esso Petroleum Co., Ltd. A C.S.L. source program is first translated into an intermediate program in Fortran, which is then compiled by the Fortran compiler in the usual way.

C.S.L. has extensive facilities for manipulating sets where entities may be added or removed, either singly or in groups, and complex tests made on the membership of sets.

A C.S.L. program is generally divided into a series of activities where each activity is a series of actions which change the state of the model. A scan through all the activities is made for every time increment, but only those activities which satisfy the initial test are carried out. Time cells may be associated with entities and the time advancement routine determines the one with the least positive value and advances time by that amount.

The extensions to C.S.L.1 include the facility of declaring sets as Boolean sets if no order is associated with the entities. In addition, the ordered sets are stored in a list structure. Both these facilities decrease the time of execution of the object program and are far more economical on computer storage.

Sets can be dimensioned and classes can be declared to be the size of a previously defined class as in C.S.L.2.

Multiple entry points can be defined which is useful for including post mortem routines; block data segments, data statements and blocked common as in Fortran have been introduced.

1900 SIMON

Simon consists of a set of Algol procedures and the simulation model is programmed as an Algol block.

A Simon block is written as three phases A, B, and C. The A phase is the initialisation of the model. The B phase consists of state changes which are a direct result of the advance of time. The C phase deals with the changes in the model which result from other changes. Thus, phase C is generally repeated until the model reaches a new steady state when no further changes are possible unless the time is advanced again.

1900 Simon is an extension of the Simon written by P. R. Hills. More generalized facilities for histograms and sampling and also a procedure to test the presence of an entity in a set, have been added.

MOBULA

In addition to the available 1900 versions of C.S.L. and Simon, I.C.T. is developing an experimental language for control and simulation models. This language is referred to as Mobula, MOdel BUilding LAnguage.

This will be an extension of Algol in the sense that it will use the Algol block structure and that Algol syntax will be a subset of Mobula.

Mobula extends the scope of Algol to include the concept of new nonquantitative variables known as members. These may form part of expressions, and appear in assignment statements.

Members may be entities, classes, sets, whose members are drawn from a specified class and queues of members. Any queue may hold any member.

Mobula incorporates the facility for associating properties with each member of a class, set or queue by means of a feature declaration. These properties may be numerical or logical values, or the name of some other member.

Various operators (drawn from the algebra of sets) are provided for manipulating members of classes, sets, and queues. In addition to these operators, special function procedures for member manipulation are provided and the facilities of the Algol for loop are extended so that the range can cover the members of a class, set or queue.

Mobula offers a range of statistical facilities including the declaration and manipulation of histograms, the choice of pseudo-random number generators, and various sampling routines.

No specific automatic time advancement mechanism is offered in Mobula, but labels and procedure names may be held in queues; this facility combined with some 'private library' procedures enables the user to have the choice of either an 'activity' time advancement similar to

that of C.S.L. or an 'event' time advancement similar to Simscript.

A special input and output program package is being planned which will include the facility for graphical output and the input of sample data.

An implementation of Mobula would attempt to economise on storage by using list-processing techniques and a special garbage collector. The aim is to have two compilers, one which compiles in a 'trace and de-bug' mode and one for use with an error free program which will produce a faster running object program. It is hoped later to produce a version which will ensure that a disc is automatically used as a data overflow area when the core store is full.

Miscellaneous

Line Drawing Computer Console

Bell Telephone Laboratories
Murray Hill, New Jersey 07971

A simple and economical console that displays line drawings, letters, and numbers in answer to problems submitted to a computer has been devised for use at Bell Telephone Laboratories. The consoles will be in or near scientific or engineering offices and tied into the time-sharing system of a high-speed computer.

Known as "Glance," (Fig. 1) the experimental console can display computed data such as graphs, plots, integrated circuit masks, and drawings. The console consists of a cathode ray tube display plus a teletypewriter linked to the computer. The computer interprets the problem entered on the teletypewriter and produces graphical instructions to display the answer. Picture signals are stored in a disc memory and sent to the console at a rate of 30 frames per second.

Simplicity and economy are achieved by supplying information from the disc to the console at a high bit rate (4 million bits/sec.), thereby eliminating the need for such console hardware as vector and character generators. Additionally, one magnetic disc memory will serve up to 32 consoles, each connected by only one coaxial cable.

Pictures are displayed on the 12-inch screen by using a matrix of 1024 x 1024 (more than one million) possible dot positions. The picture is formed by incremental dot commands, each of which cause the CRT beam to move one step left, right, up, down, or diagonally.

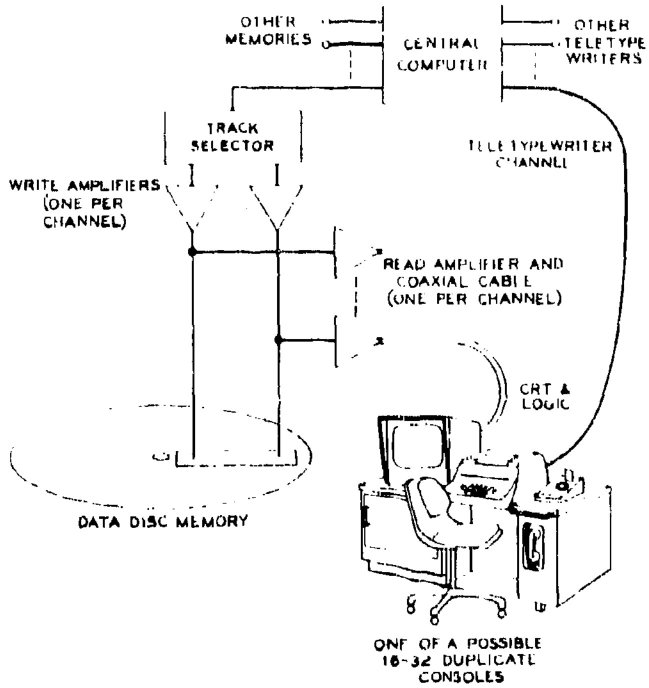

Fig. 1 - "Glance" console system

Humanities and Social Sciences Research

University of Pennsylvania
Philadelphia, Pennsylvania 19104

A Center for Computer-Oriented Research in the Humanities and Social Sciences has been established at the University of Pennsylvania.

Dr. Bernard W. Wishy, a systems advisor for International Business Machines Corporation and former Columbia University faculty member, is director. He assumed full-time duties as Center director on January 1, 1967.

"The Center will work in three areas," Dr. Wishy has explained. "In information and instruction, it will publish periodic indexes of all known work in the humanities and social sciences using computers. It will conduct special courses and seminars on campus for Pennsylvania faculty and students, and it will provide research facilities for national and foreign fellows of the Center.

"It will provide an organization so that various models can be created to provide more extensive data processing services for scholars in the humanities and the social sciences. These services will include specialized systems analysts and programmers.

"The Center will be involved in research and publication," Dr. Wishy continued, "on broad general areas such as content analysis, in which computers analyze texts and other media for their grammatical, intellectual, or symbolic meanings and patterns. This could, for example, authenticate editions, establish predominant themes in literature, and ow the indebtedness of an author to another.

"We also hope to establish links between computers and photographic files for storage and retrieval, and to publish a series of volumes on the problems and uses of computers in individual disciplines."

"We shall use the University's Computer Center computers for the foreseeable future," he points out. Underlining this intention, he credits Dr. Lee Benson, professor of history, and Dr. John F. Lubin, director of University Computing Activities and associate professor of industry, with laying the groundwork for the Center. The IBM Corporation has provided financial assistance for the Center.

First project of the Center to see fruition is a series of lectures on "The University and the New Technology," now being given monthly to invited Pennsylvania faculty members. The series will include a description of changes computers are bringing about in the analysis of literary texts and a discussion of the problems in planning the new computer-oriented campus of the University of California at Irvine.

Explaining the lecture series, Dr. Wishy has commented "The use of computers, xerography, microphotography, and other new devices is accelerating in most disciplines at a remarkable rate.

"Increasingly, also, many academic persons are involved in national and international projects concerned with the rationalized use of this new technology for the general convenience of their scholarly guilds. These projects involve data banks, information retrieval, bibliography control, and other automated or semi-automated systems.

"Pennsylvania's Computer Center this summer is planning to install a new computer of very great power, the IBM System/360 Model 67. Eventually, it will be capable of placing many users simultaneously in touch with the central processing unit through such devices as console typewriters and small display screens located in faculty offices, laboratories, and libraries. These changes are likely to affect fundamentally the organization of the scholarly community and its means of communication, the standards of research and intellectual performance, and the undergraduate and graduate curriculum."

Now being planned is a course, probably offered initially without credit, in which Dr. Wishy would examine some of the principal types of computer applications in the humanities and social sciences. Without delving into programming, the course for graduate students, faculty members and selected undergraduates will describe resources available at Pennsylvania and elsewhere so that interested scholars can properly launch computer-oriented research projects.

"This Center," Dr. Wishy claims, "will be the first in the world to take a national and international view of what are, in fact, common problems now being approached by individual scholars working in isolated areas. They are, in reality, reinventing the wheel daily.

"In the area of bibliographic control, for instance, large-scale interdisciplinary efforts are already underway. A scholar can get from

a data bank the statistics which interest him, or the results of work which has been completed recently in his area. This eliminates the frustration and wasted effort of duplication."

The director emphasized that "The Center's concerns are primarily scholarly, not technological. It has not been established to do things with machines just for the sake of the technology involved.

"The primary purpose of the Center," he continued, "will be to present the University of Pennsylvania as a model and as an international training and information institution, showing what can be done to advance the use of computers by students and teachers in the humanities and social sciences."

Periodically the Center will compile and publish a continuing index of computer work in the humanities and social sciences, using computer prepared indexes and abstracts.

Volumes on the work of computers in various applicable fields will be commissioned. These will consist of essays describing the history and special problems of computer usage in a humanity or social science, followed by a series of papers illustrating various computer applications.

The Center also will create and collaborate with other institutions in creating a national repository of outstanding and most-used computer programs. These will be available through the normal channels between university computer centers.

Regarding the need for the Center, Dr. Wishy points out that "No one really knows the extent and quality of current American work in data processing for the humanities and social sciences. Information filters through in bits and pieces from various agencies and publications, but we have nothing approaching recent thick inventories of work in biology and medicine.

"Most American university computing centers are still oriented predominantly toward scientific and administrative work. The special needs of other scholars are dimly understood and poorly aided because of this tradition."

Pennsylvania's new Center is dedicated to ending the frustrations of just such scholars.

FOSDIC IV For Microfilmed Weather Data

National Bureau of Standards
Washington, D.C. 20234

An improved model of FOSDIC—Film Optical Sensing Device for Input to Computers—has been completed by the National Bureau of Standards (U.S. Department of Commerce) for use with the computers of the National Weather Records Center at Asheville, N.C. FOSDIC IV, designed under the direction of Ervin C. Palasky of the NBS Measurement Engineering Division, reads data on past weather conditions from microfilms of punched cards from the Center's archives (Fig. 1). The machine performs logical operations on the data it reads and also selects certain data to be recorded on magnetic tape for later input to digital computers. This will enable past weather conditions to be compared with more recently gathered data, so that the Center can study long-range weather patterns and improve its present prediction services.

The first FOSDIC* was produced by NBS for the Bureau of the Census to read marked documents in experimental and special data processing applications. NBS later produced FOSDIC II to enable the Weather Bureau to duplicate microfilmed punched cards, FOSDIC III for use in the 1960 Census, and a partially transitorized version in ACCESS (Automatic Computer Controlled Electronic Scanning System) for the Office of Emergency Planning.†

The newest model, FOSDIC IV, also is partially transistorized and in design is especially adapted for rapid scanning and selection of data,

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*Earlier versions of FOSDIC are described in "FOSDIC III To Assist In 1960 Census," NBS Tech. News Bull., 43, 106-107 (June 1959);
"FOSDIC II Reads Microfilmed Punched Cards," NBS Tech. News Bull., 41, 72-74 (May 1957); and
"FOSDIC—A Film Optical Sensing Device for Input to Computers," NBS Tech. News Bull., 38, 24-27 (Feb. 1954).

†"Direct Communication Between Man & Computer; ACCESS System Will Process Emergency Data, NBS Tech. News Bull., 50, 53-54 (Apr. 1966)

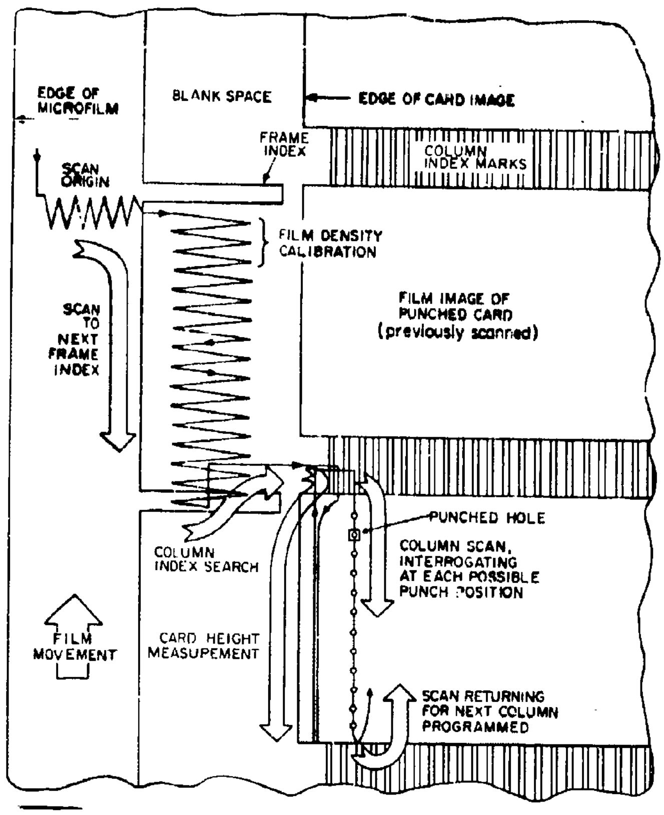

Fig. 1 - Weather data on microfilm of punched cards are read at high speed by FOSDIC IV, a computer accessory designed at NBS. FORSDIC's scan must register precisely with card punch marks on the microfilm; this is accomplished by reference to opaque marks on the film. The broad arrows indicating parts of the scan show it referring to the frame index at the top of the card and to a column index directing the scan to the desired column.

reading from microfilms of punched cards at the rate of 2,000,000 bits per minute, compared to the 500,000 of FOSDIC II. This rate corresponds to a column-by-column examination of 2,000 full cards per minute and up to 8,000 cards per minute when examining fewer columns.

FOSDIC II can also re-sort input data, as in performing computations producing new data, whereas its predecessor FOSDIC II could only duplicate selected cards in their entirety. Data to be recorded are translated into the most suitable code for recording on magnetic tape and subsequent use by a computer.

MICROFILMING PUNCHED CARDS

The weather data of the National Weather Records Center are contained on 400 million punched cards which are now being microfilmed to take advantage of the greater data density of microfilm and the rapid access obtained by use of FOSDIC. The cards are photographed with an anamorphic lens which reduces card size by a factor of 43-to-1 vertically and 24-to-1 horizontally, compressing the image so that the rectangular punches appear as 0.06-mm squares. (See Fig. 2.)

The images run across the 16-mm microfilm, appearing as narrow bands numbering approximately 11 card pictures to the inch. The cards are filmed at a rate of 800 per minute through a continuous flow filmer developed at the Bureau of the Census. Each 100-foot reel of microfilm holds the images of up to 12,000 punched cards. The microfilm negative is retained in a master file after a positive film is

Fig. 2 - Microfilm on which weather data are recorded is read at high speed by FOSDIC IV, an NBS-designed machine, at the Weather Bureau's National Weather Record Center. The image of each punched card on the microfilm positive has been so reduced vertically that the punches appear as squares on the image, making for maximum efficiency of storage and retrieval. The small spike beside each card image is the frame index, essential for precise registration of the scan with the image.

produced for the working copy. On the working copy films, the punched holes appear as transparent spots surrounded by the opaque background of the card stock. Figure 3 shows microfilm being threaded onto film transport.

FLYING SPOT SCANNER

The data contained on a microfilm frame are probed by projecting the image on the face of a cathode-ray tube (CRT) through the film. The light transmitted by the microfilm image at successive positions of the luminous CRT spot is sensed by a photoelectric cell. If the CRT scan is controlled to run down each column of the microfilmed card, it will produce as a signal a running measurement of the transmissivity of the microfilm along the scan when compared to a threshold, in effect, a series of digital data contained on the card. The scan may be contrived to examine only areas of interest by programming the motion of the CRT beam.

Scanning must be extremely accurate in order for the beam to pass through each punch despite variations in card position. This accuracy is obtained by reference to the top edge of the card for vertical registration and to column marks for horizontal registration, as a card is normally viewed. This is accomplished by moving the beam, after each scan, across the film to the left edge of the frame area and down until it reaches the index mark of the next card, at the same height as the top edge of the card. The vertical height of each card is then measured in a preliminary sweep to enable FOSDIC to take into account slight variations in size produced by the high-speed, continuous flow filmer.

The beam is moved across the column index marks until it reaches a column programmed for examination and then downward from the top of the card, which is the vertical reference for subsequent data location. The film opacity is interrogated at each of the 12 possible punch positions in the column and all punches on the card are stored as digital data in a real time memory. Data selected for recording, as a result of logical examination, are passed on to another memory,

Fig. 3 - FOSDIC IV was designed at NBS to enable the Weather Bureau to retrieve archival weather data from microfilm. The data obtained are recorded on magnetic tape by the recorder at the left; the other racks contain logic, memory, scan control, and film advance circuitry. Data selection and logical manipulation are determined by the wiring on the plugboard.

an 80-column register, from which they are transferred to magnetic tape.

DATA ACCEPTANCE

The card columns scanned and the data selected from them are determined by the wiring of FOSDIC's 2560-hole plugboard, as is the logical treatment the data are subjected to. The plugboard is removable, so that FOSDIC can be programmed to read and treat the data for different programs or cards by merely inserting the proper plugboard.

FOSDIC IV has a more extensive bank of logic elements than previous FOSDIC models, allowing more editing, shifting, and compacting operations to be performed. These logic operations are carried out by circuitry capable of making 240 "AND" or "OR" decisions during each card scan. At this stage the data can be shifted, constants entered, and new data entered, from reduction or combination of the original data as programmed by the plugboard.

When the 80-column storage register is full the contents are passed serially through a converter for translation from 12-bit Hollerith to 6-bit-plus-parity binary or binary-coded-decimal, whichever is compatible with the next computer operation. Then the data are recorded on magnetic tape, which runs only during such recording operations.

ERROR SUPPRESSION

During normal sensing the microfilm moves continuously, but can be stopped on operator command or when the logic identifies an invalid data combination, incomplete data, or cards having certain preselected data combinations. The card at which the operation stops is presented for the operator's inspection on a viewing screen and its data content is indicated by a bank of lights. The operator can enter a correction if he wishes and then trigger the machine to resume operation.

Computer Control of Jet Engine Testing

Oklahoma City Air Materiel Area
Tinker Air Force Base, Oklahoma

The Oklahoma City Air Materiel Area (OCAMA), at Tinker Air Force Base, is using the first fully automatic control system to test jet engines.

"If this system adds just 1 hour to the usable life of every jet engine between overhauls, it will save more than $6 million," said Maj. Gen. Melvin F. McNickle, OCAMA Commander. "We test 81 percent of all Air Force engines here in direct support of the war in Vietnam and our global defense system. Automated assistance can both increase our operating efficiency and increase flight safety."

Col. F. D. Berry, Jr., Director of Maintenance, said the need for a control system is implicit in OCAMA's workload. "We are the primary overhaul point for jet engines used on B-52 bombers and KC-135 tankers. OCAMA is the only Air Force facility overhauling both pure jet and turbofan engines. The annual workload includes 3,300 Pratt and Whitney J-57, J-75, and TF-33 engines and General Electric J-79's in all types, models, and series.

"Manual recording, evaluating, and physical control in the test process has been subject to human error. Electronic control has reduced this error potential.

Currently, an IBM 1710 is controlling the testing in one of the eight test cells at Tinker AFB. Alvin P. Hanes, Chief, Industrial Engineering Division, described the operation of a cell:

"Testing is essentially an industrial process. The engines are dismounted from aircraft throughout the world and shipped to Tinker AFB. After overhaul and/or repair we mount the engine in a test cell, attach a variety of sensing devices, and by using operator entry devices the control system starts the test. Readings are made as the engine idles, accelerates, and runs at various throttle positions under both primary and emergency fuel control systems.

"In short, we put the engine through its paces and record its performance. One year's testing involves more than four million recordings, 160,000 plot points, 80,000 calculations and 270,000 annotations. The data processing problem has been monumental."

Now, however, the control system does the job automatically, recording data as the test progresses.

The control system operates the throttle, trim control, afterburner, and similar physical elements of the engine; it takes all required readings, calculates and prints the results in both numerical and graphical form.

"What's more, "Mr. Hanes said, "all the data is available long after the test so that we can analyze, summarize, and interpret it to prolong the service life of engines and predict mechanical faults."

William H. Richardson, Chief of the Engine Engineering Branch, described the system's characteristics.

"The equipment monitors 40 sensing devices on the engine. Every 3.6 seconds, it checks eight critical values. If it spots dangerous situations, it will either output an operator message or shut down the engine automatically. The control system also opens and closes a variety of switches as it starts, operates, and stops the engine."

At the end of each test, a complete print out is available for future analysis and becomes part of the engine's historical file.

"Because background data will be kept and can be processed extremely fast," Mr. Richardson said, "we expect to operate not only as a testing facility, but also as a data source for in-service engineers. As added bonus, from a testing perspective, however, will be the standardization of both test procedures and data recording."

CHP's Auto-Statis On-Line with National Crime Information Center

California Highway Patrol
Sacramento, California

The opening phase of a nationwide computerized crime information system was set in motion in January 1967 through a linkup between computers in Washington, D. C. and Sacramento, climaxing a year's planning and activity by national committees led by Californians. Announcement of the connection was made jointly in Sacramento by California Attorney General Thomas C.

Lynch and California Highway Patrol Commissioner Harold W. Sullivan, and in Washington by the Federal Bureau of Investigation.

Ultimately, the system is expected to provide close to 40,000 law enforcement officers in California with critical and rapid knowledge of wanted persons, stolen goods, and stolen vehicles. But, to start with, operating through the California Highway Patrol's AUTO-STATIS System, (AUTOmatic STatewide Auto Theft Inquiry System), only vehicle information is being exchanged on a test basis.

The Highway Patrol AUTO-STATIS System, using an IBM 7740 communications control system, which furnishes peace officers everywhere in California with immediate information on stolen or wanted vehicles and stolen or lost license plates, have been operating since the spring of 1965. It will be the western switching link for the nationwide system. The computer in Washington, operated by the FBI, is to be called the National Crime Information Center (NCIC), and will be a nationwide index of law enforcement information on crimes and criminals.

The California Department of Justice is also joining the system with a computerized file which will include persons wanted in a felony, stolen or lost firearms, and stolen or lost properties identifiable by a serial number. This unit will be tied directly into AUTO-STATIS in California and the NCIC computers in Washington, and for the present, will complete the California end of a system that will initially include agencies in 12 states. Ultimately, the computerized information system will be expanded to encompass the entire United States. When the initial system becomes fully operative local police officers anywhere in California will be able to make an immediate check on a suspicious car, a suspicious person, or property suspected as stolen, and receive a response within a minute. Inquiries made will be carried by the California Highway Patrol communications system to AUTO-STATIS and be automatically switched either to the California Department of Justice file or to the NCIC in Washington as may be required.

With the objective of improving the effectiveness of law enforcement through more efficient and rapid exchange of the critical information, the system was designed to complement statewide and metropolitan systems. Planning began in work sessions of the International Association of Chiefs of Police where three committees were established to work out procedures and policies to be followed in establishing NCIC. All three committees were headed by Californians: California Highway Patrol Inspector D. S. Luethje was chairman of the committee on stolen vehicles; O. J. Hawkins, Assistant Director of the California Department of Justice was chairman of the committee on property and firearms; and E. V. Comber of the San Francisco Police Department, now of the California Department of Justice, was chairman of the committee on wanted persons.

The IBM 7740, located at the Sacramento headquarters of the CHP has been assisting law enforcement agencies throughout a five-state area in recording and disseminating centrally stored information about stolen vehicles and stolen or lost license plates. The system went into operation in April 1965. It contains more than 60,000 license and vehicle identification numbers.

Each day approximately 13,000 inquiries are made by law enforcement agencies in California, Nevada, Arizona, Washington, and Oregon. An IBM System/360 Model 30 is used to prepare a daily log of these inquiries and for statistical analysis of stolen and recovered vehicles.

Inquiries are made into the AUTO-STATIS System from IBM 1050 data communications terminals or Teletype terminals located in law enforcement agencies in major cities on the west coast. The 1050 communicates directly with the IBM 7740 which in turn automatically routes messages to the FBI's NCIC. There are approximately 150 terminals connected to the 7740.

By linking AUTO-STATIS with the NCIC, a terminal in Los Angeles used for making inquiries about stolen vehicles now has access to the two IBM System/360 Model 40's at the FBI's Washington, D. C. headquarters. AUTO-STATIS continues to provide information about stolen automobiles. In addition, it now supplies information about stolen automobiles and license plates, stolen property, warrants, and gun registrations filed at the NCIC.

When stolen vehicle reports are received by local law enforcement agencies in the five-state area, they are immediately filed in the AUTO-STATIS System. This is done by the reporting agencies which send the information to Sacramento on punched paper tape or on punched cards. This information includes: license number, state of registration, vehicle identification number, year, make, body style, color, date reported stolen, reporting authority, and file number. Also, each report contains up to 48 characters which can be used to inform the police

officer making the inquiry whether the car was stolen in the commission of a crime, if the driver is believed to be armed, and other pertinent information.

Similar reports formerly took from 24 to 48 hours to compile because of the slower methods of communication between law enforcement jurisdictions.

In the event of a breakdown of the AUTO-STATIS System, a duplicate system is standing by ready to take over operation.

Computerized Traffic Control

City of Wichita Falls
Wichita Falls, Texas

Wichita Falls has become a city of green lights. At city hall in this growing community of 110,000 people, a new computer is at work trying, whenever possible, to eliminate unnecessary automobile stops.

The computer, an IBM 1800 data acquisition and control system, is the first of its kind to be installed for traffic control. "Preliminary results," said Jack Davis, city manager, "show a significant improvement in the flow of cars in and out of the city during peak hours."

The computer is operating traffic signals at 54 intersections in a 47-square block area of downtown Wichita Falls, Mr. Davis said. These signals are connected directly to the control computer by wire.

The 1800 system absorbs information about the flow of traffic from 19 pressure-sensitive devices buried in the pavement at strategic locations throughout the city. As cars pass over these devices, an electrical impulse is sent to the computer, which can gather and analyze millions of bits of information each second.

"In this way," said Mr. Davis, "the computer is informed of any traffic demands and can respond accordingly by changing traffic signals. By early next year, 32 additional sensing devices will be installed to increase the amount of data for the computer."

Roy Wilshire, city traffic engineer, indicated that the new devices will have the ability to detect not only the number of cars, but also their speed, the lane they are in, and the number of stops that they make.

"With the 1800 system," said Mr. Wilshire, "we have a control computer that is capable of immediately responding to the needs of traffic." Presently, the computer selects the best of 17 different traffic light timing sequences. Eventually, it will be programmed to develop an infinite number of patterns to meet the constantly changing demands of traffic.

Mr. Wilshire said the IBM 1800 provides a central location where all traffic data can be studied and controlled. "We have learned more about our downtown traffic here in the past few weeks from the computer than during the past 15 years by observation." he said.

The computer control system has the ability of turning itself on and off automatically. It also can operate unattended during the day. When not in use, the city's former fixed-time system takes control.

Mr. Wilshire said plans are underway to use the 1800 for studying the traffic capacity of various streets to determine if they should be widened, conducting downtown parking turnover studies, and scheduling maintenance of traffic signals, detectors and other equipment.

Computerized Motor Vehicle Records

State of Illinois
Springfield, Illinois 62706

The state of Illinois has declared an all-out "war on paperwork" in an effort to win once and for all the state government's continuing battle to provide more service and better information at less cost.

Paul Powell, secretary of state, said a powerful new ally—an IBM System/360 Model 50—will be brought into the action, "When put into full operation, it will help turn the tide in our favor dramatically and permanently."

Major activities of the Secretary of State's office which will be affected are driver and motor vehicle licensing and vehicle registration.

"The versatile IBM system eventually will enable us to save the taxpayers millions of dollars through its ability to quickly and accurately process the 20 million documents that must be produced by this office each year," Mr. Powell said.

"In addition, its speed and data storage capabilities will permit us to economically perform tasks that are necessary but impossible under current procedures."

The Secretary of State has mapped out a comprehensive 7-year plan aimed at getting the most out of the $5 million electronic system.

The objectives of this program include:

- Working with the Department of Public Safety to establish a statewide communications network and information pool on all vehicle-driver records. Law enforcement officials, municipalities, and other agencies needing accurate and timely data from the Secretary of State's office will have fingertip access to information stored in the computer's files.

- Elimination of the "Wheel Book," the voluminous printed list of Illinois motor vehicle license numbers and owners. This will result in a savings of $420,000 per year.

- Construction of an electronic system that will enable the Secretary of State's office to keep pace with skyrocketing requirements to process, store and distribute information on Illinois' 5-1/2 million drivers and 5 million vehicles—and to do this without proportionate increases in costs.

According to Mr. Powell, the key to the plan is the System/360's ability to store vast amounts of data "on-line," or immediately accessible for processing, updating or inquiry.

"Stored in nine IBM 2314 magnetic disk data storage units will be information on all the state's licensed drivers and motor vehicles," Mr. Powell said. "In addition, we will maintain electronic records on 20 million motor vehicle titles; 126,000 corporations that do business in Illinois; 5 million catalog items for the Illnois State Library; and an inventory of 6,600 office supply items.

The main benefits of this direct access data storage are centered in two broad areas, according to Mr. Powell.

"In the first case, we will be equipped to handle our increasing daily workload much faster and more economically," he said. "For instance, state motor vehicle registration is growing at a rate of more than 210,000 per year. The system will handle increase with ease."

The Secretary of State listed a few of the computer's planned tasks: Issuing and renewing an average of 17,000 drivers licenses each day; providing 11,000 abstracts of driver records to courts and insurance companies daily; recording up to 5,000 traffic violations each day; and, from December to February, renewal and transfer of 6 million vehicle licenses.

Secretary of State Powell pointed out that the fees the state receives for providing the driver histories—more than one million dollars a year—pay for the computer. "And this is a job that we just couldn't do without the system," he added.

The second broad area is concerned with law enforcement.

Mr. Powell explained: "In cooperation with the Department of Public Safety, we plan to build a statewide communications network. Law enforcement offices and municipalities will be linked directly to the computer in Springfield by telephone lines and special Tele-processing terminals, devices which resemble small television sets with attached typewriter keyboards.

"All or any part of the driver and vehicle information stored in the computer is thus placed at the fingertips of an official with a requirement for that data. An operator need only key in a special code and a driver or vehicle license number and the information is instantaneously called out of storage and displayed on the terminals's cathode ray tube.

Mr. Powell gave two examples of where this "instant information" would be invaluable.

A police officer with an automobile under surveillance can radio the license number of the vehicle in question to a district office. An operator there keys the numbers and code into the system and reads the information back to the officer as it is displayed on the television-like tube. The entire operation will take less than 2 minutes.

Before stopping the automobile, the police officer thus has at hand data on the driver's record and the vehicle's legal registration. Because the computer's files will be continuously updated with information on vehicle-connected

crime, he also will know if the car is stolen or the driver wanted.

"This increases the efficiency of each police officer and it gives him greater ability to deal with potentially dangerous situations," Mr. Powell said. "Similar information isn't available now and even the most basic data on drivers takes an average of 42 minutes to retrieve and relay to the waiting officer."

Mr. Powell's second example deals with elimination of the Wheel Book which often isn't available in its entirety until July.

"This means that from Dec. 1 to July, cities cannot match an automobile license with the car owner's address. This delayed identification costs the cities of Illinois millions of dollars in uncollected parking fine revenue.

"The electronic system not only will save the $420,000 spent each year in publishing the Wheel Book, it will solve the loss of revenue problem. Each municipality can query the system for the most current license information through the communications terminals. Since the files will be updated every day, there will be no time lag in matching a new license number to the vehicle's owner."

Computerized Statute Retrieval System

Iowa Legislative Research Bureau
State House
Des Moines, Iowa 50319

In December, the Iowa Legislative Research committee formally announced details of an electronic statute retrieval system that will put the research power of a computer at the fingertips of the state's 61 senators and 124 representatives.

Sen. John P. Kibbie, Democrat from Emmetsburg, chairman of the bipartisan joint committee, said:

"The 2,988 pages of state laws and the 30 pages of the Iowa Constitution have been indexed and electronically stored in an IBM computer. Any section pertinent to pending legislation now may be called out merely be coding in key words.

"The computer searches the law and prints out at the rate of one typewritten page per second those sections dealing with the subject under consideration."

Rep. C. Raymond Fisher, Republican from Grand Junction, committee vice-chairman, said, "Any lawmaker considering a new bill or amendment may ask the Legislative Research Bureau questions. The printed answers will be ready at the opening of the next day's session."

Key item in the law retrieval system is an IBM System/360 Model 40. Gene Reyhons, Bureau director, said: "In addition to tremendous time savings, the new computer is completely accurate in its reporting for the Legislature if the system is used properly."

He said a research project 2 years ago, supporting a study of Iowa courts, took four researchers 40 man-days to read the entire code. They sought sections containing the phase "term of the court." Mr. Reyhons noted:

"The System/360 takes just 10 minutes to handle a similar problem—and without the element of human error."

Mr. Reyhons said the new system will free researchers from laborious, manual searching. "Out staff members will devote their time to more demanding tasks, such as preparing and sharpening questions to be put to the System/360," Mr. Reyhon said. "The appropriateness of the answers is directly related to the degree of accuracy and explicitness of the question.

"We have a 250-page index of words and phrases," Mr. Reyhons said. "From it we can locate those sections of the law and the constitution pertaining to the question at hand. The system requires no knowledge of computers, but our researchers must be familiar with the law and with traditional search techniques." For example, he said, a lawmaker asking for Iowa statutes concerning fences will receive, overnight, printed sections of the law containing the words "fence," "enclosures," and related terms.

In March, the State Budget and Financial Control committee, headed by Sen. George O'Malley, Democrat from Des Moines, allocated $50,000 to tailor Prof. Horty's system to Iowa needs. In November, the System/360 was installed and Prof. Horty's programs were stored in its internal memory.

When the General Assembly convened January 9, any lawmaker, committee, agency, or

state university could have access to the working system.

The computer is under the auspices of State Comptroller Marvin R. Selden, Jr. He emphasized the Model 40 will be used for many tasks in addition to statute searching.

"Our centralized data processing services are used by 36 agencies of state government," he said. "We do all state accounting, prepare checks for 6,000 persons on state payroll, maintain records on 1.8 million drivers licenses, account for and pay 40,000 welfare recipients each month and perform scores of other data processing tasks.

"Right now, we are implementing the state withholding tax accounting program. We add more applications every year as we continue centralizing State of Iowa data processing activities.

Computerized Medical Library

Medical College of Virginia
Richmond 19, Virginia

The Medical College of Virginia announced it has begun using a computer to index its 80,000 library books and ultimately plans to put the index into the hands of the state's doctors.

An IBM 1410 computer is being used to produce library catalog cards, and by reclassifying the same information into page form, also to produce a publishable book catalog.

The index cards, which give the title, subjects, and call numbers of the books in the Tompkins-McCaw library, emerge from the computer's high-speed printer, attached edge to edge, in streamers. They can be produced at the rate of 40 a minute.

The book catalog—an abridged edition of the cards—comes from the computer ready to be copied and printed. Long-range plans call for distributing this catalog to Virginia's 4,850 physicians.

Computerizing of the library's catalog was undertaken as a pilot project by the college to test its feasibility. "We've made our initial runs and they've been successful," said Richard A. Pace, director of systems and planning for the college.

"We're scheduled to have the library's book holdings from 1940 to the present indexed by December of next year," said Mrs. June Leath Huntley, library director, "then possibly extend it, on a cooperative basis to other medical libraries in the state."

With the computerized index in their hands, Virginia's doctors could be led directly to important sources of medical information within the state.

The computer-aided recataloging of the library, which is still in the pilot project stage at the Medical College of Virginia, is using subject headings designated by the National Library of Medicine in Bethesda, Md., to meet the needs of the medical profession.

The computer is printing the new standard cards at a rate of about 10 lines a second, according to B. L. Dixon, systems analyst who directed the development of the complex program that instructs the computer.

The cards have been specially die-cut to fit standard library catalog drawers and travel through the printer in streamers, carried along on perforated tracks that are stripped off afterward.

The first step in the recataloging of a volume begins at the library where Mrs. Louise Bryson, project supervisor for computer cataloging, determines the information to be entered on each card, appropriate coding, and required cross-reference headings.

The library information is punched into cards at the computer center. The punched card system simplifies updating or correcting single lines or entire entries. The computer sequences the information and automatically orders printing of additional cards according to the coded variety of subject headings entered for each volume.

The computer also provides an abridged listing without cross-reference subject headings as the format for a publishable book catalog. The first index has been published and circulated to the staff of the Medical College of Virginia.

"This book catalog simplifies the search for information by the staff outside the library," Mrs. Huntley said. "We decided to recatalog according to the latest standards, and began work in May 1966. We hoped then we could simultaneously produce a card and book catalog, and thus far the system has demonstrated it can."

Computerized Auto Crash Simulation

Cornell Aeronautical Laboratory, Inc.
Buffalo, New York 14221

A computer simulation of an auto crash victim during head-on collisions is proving a valuable and economical research tool in evaluating new protective devices.

The simulation, developed by Cornell Aeronautical Laboratory, consists of an 11-degree-of-freedom, nonlinear, mathematical model of an anthropomorphic dummy, a belt-type restraining system, contracted surfaces in the vehicle interior and a vehicle or test sled compartment. The system response is calculated in the form of time histories of the forces, accelerations, velocities, and displacements at various points in the dynamic system. A time-history of the detailed energy distribution within the system is also calculated.

The two-dimensional simulation, developed initially under funding from the U.S. Public Health Service and the Automobile Manufacturers Association, and now being supported by the Injury Control Program, Public Health Service, was recently compared with crash experiments. The results of sled tests substantially agreed with the results of the computer simulation. A dummy, rather than a human being, is used in the simulation so that such experimental comparisons can be made.

At present, CAL is using the new technique to evaluate the effects of lap and shoulder harnesses in a frontal impact.

Results thus far have led the scientists to believe that computer simulation can serve as a valuable supplement to car crash experiments and sled tests, both commonly used for restraint system evaluation.

Among advantages cited for the computer simulation technique are economy and repeatability. CAL reports that computer simulation can produce data at a fraction of the cost of an actual car crash or sled tests where equipment and interpretation of data run into thousands of dollars. Repeatability of test conditions, an important factor when analyzing variables in a system, is extremely difficult to achieve in car crash experiments. With a computer, repeatability is not problem, CAL reports.

The heart of the mathematical model employed in the simulation is a general subroutine for calculating nonlinear load-deflection for each of the major system forces (i.e., restraint belts, contacted interior surfaces, and car stopping devices.) The load-deflection relationship for increasing load is represented by general polynomial function of deflection and the velocity of deflection. For decreasing load, the load-deflecion is represented by a parabolic function of deflection that is determined from specified ratios on conserved energy to total absorbed energy, and residual deflection to maximum deflection.

Also under a contract with the Injury Control Program, Public Health Service, extensive measurements of an anthropomorphic dummy were performed by CAL in order to define completely the physical properties of individual segments. Measurements covered length and weight of segments as well as center-of-gravity positions and moments-of-inertia. Equally extensive data were obtained on belt, seat and target characteristics. The targets were energy absorbing objects simulating steering wheel and dashboard impact areas for the dummy's head, chest, and knees.

Since a graphic visualization of the simulation is desired along with tabular output, the scientists at CAL have a 7044 computer drive a graphical plotter as it processes the simulation. The results are a sequence of drawings showing the positions of the dummy in relation to the compartment, seat, and targets during deceleration at pre-selected time increments. This "pictorial" display actually enables the engineers to see the effects of a specific restraint and compartment configuration on a body subjected to deceleration forces during impact.

To further extend the "realism" of the simulation, the CAL scientists have produced "computer generated" movies The movies show the output of a high-resolution flying spot scanner driven by the simulation program in the computer.

The flying spot scanner traces the figure of the dummy, car seat, floor board, restraint belts, and interior surfaces of the vehicle with a 0.002-inch dot of light. As with the graphical plotter, a new position is generated for every real-time interval of 0.001 second.

A single frame, remote pulse operation is employed for shooting the movie. A 16mm camera is aligned in front of the scanner's cathode ray tube with the shutter opened to expose a single frame for each display. Although faster speeds are possible, the flying spot scanner traces each figure in 0.7 second.

Since the scanner does not have an image retention capability, each drawing or display is actually a sequence of closely spaced dots of light. On the photographic image, the dots merge into solid-appearing lines.

When the motion-picture film is projected at various speeds, including real time, researchers have a precise visualization of a dynamic computer simulation.

While the present two-dimensional simulation is of a frontal collision only, CAL scientists say that side collisions and rear collisions can also be simulated in the same way. Three-dimensional simulations, involving angular or oblique vehicle impacts, will ultimately be possible, they say.

Computerized Industry Model

National Bureau of Standards
Washington, D.C. 20234

The tufted carpet industry has been simulated by a mathematical model developed by Gary C. McKay and Jerome Yurow, of the NBS Institute for Applied Technology (U.S. Department of Commerce), in cooperation with the Tufted Textiles. Manufacturers Association and with the contract assistance of Management Science, Atlanta. The model has as variables the policies used by retailers, wholesalers, manufacturers, and yarn suppliers to maintain inventories. It enables operational policies to be altered by the experimenters and the consequent behavior of a typical business in the industry to be studied. The model (Fig. 1) simulates the flow of goods in the industry: operating the model with reduced inventories, for example, demonstrated that such a basis may be practicable for sectors of the industry. Although the model simulates the tufted carpet industry, its primary purpose was to demonstrate the usefulness of the technique for other industries as well.

SIMULATION

Simulation—representing an action or object by other than its actual size, materials, or relationships—has become increasingly useful to scientists. It enables pilots to be trained without leaving the ground, materials to be tested for response to exotic environments (the jungle, the moon, or in a corrosive atmosphere), and the handling and seaworthiness of ships to be determined while still on the drawing board.

Computer manipulation of mathematical models offers an effective way of simulating the operation of systems which can be described numerically. The Institute's Technical Analysis Division uses such models in much of its work. In the present case it sought to demonstrate how such a model can simulate an industry composed of consumer, retailer, wholesaler, manufacturer, and supplier of raw materials. (See Fig. 2.)

MODEL OF AN INDUSTRY

To set up the model of the tufted carpet industry, the Bureau study group got information on details of industry operation by visiting plants and asking a series of questions at each. The investigators decided to represent the industry by "sectors": the retailer serving the consumer, a wholesaler in some cases, a carpet tufting and finishing manufacturer, and a yarn supplier. The individual businesses in each of these sectors were found to maintain similar inventories and to use similar ordering and stocking policies. The collective consumer sets the demand for the entire industry, each unit of which attempts to maintain fixed inventory during all ups and downs of business.

MANUFACTURING CARPETING

Tufted carpets are made by banks of needles which thrust loops of yarn through jute fabric,

Fig. 1 - Carpeting flows through various stages of manufacture and distribution, from the wool and acrylic yarn mills to the retailer. Not shown is the reverse flow of orders, simulated in an NBS model of the industry, which enables each mill and dealer to maintain its inventory.

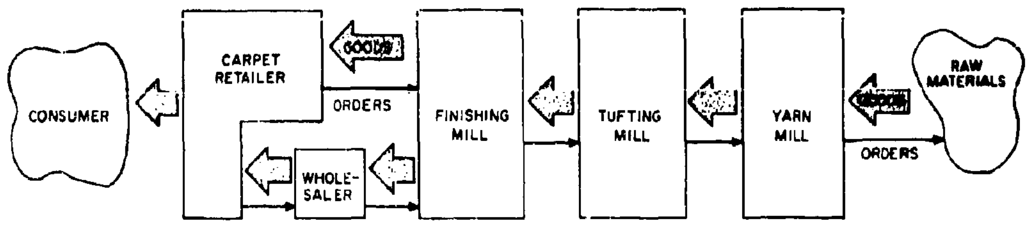

Fig. 2 - Operation of the tufted carpet industry is described by an NBS model in which goods being processed flow through various mills to retailers, which sell the finished carpeting to consumers. A reverse flow of orders governed by the model maintains inventories in each sector at the levels actually found in the industry.

the back of which is then coated with adhesive and covered with layers forming the base of the carpet. More than half of the industry's output is made as greige (gray, or uncolored) carpeting in several widths which are kept in stock to be "piece-dyed" in any color needed.

A smaller proportion of the output is "stock-dyed"—made from colored yarn. A typical mill produces carpets by both methods in 2 or 3 widths, 5 to 10 patterns (formed by variation in pile density and thickness), and 10 to 20 colors. The tufting mill is treated in the model as producing four lines of carpeting: greige carpeting for inventory, greige carpeting for special order, stock-dyed carpeting for inventory, and stock-dyed carpeting for special order.

Finishing consists of attaching the backing, dyeing the carpeting, and forming carpets by shearing, edging, and cutting. Finishing operations are sometimes performed under the same roof as the tufting, but the finishing sector maintains its own workflow and inventory like a separate concern. However, the total tufting production of a tufting and finishing factory can typically be finished within the factory without creating a pileup of unfinished carpeting, so the two areas were consolidated in the study.

The most detailed sector of the model was the tufting and finishing mill, the demands on which were regarded as being set by the consumer through the intermediacy of the retailer and wholesaler. Labor was regarded as fixed in cost, but the effect of labor practices with respect to abrupt changes in the workweek were included in the model. The mill was assumed to have fixed productive capacity, unrestricted by yarn supply, transportation, storage, or finishing capacity.

VALIDATION OF MODEL

The model was validated by operating and adjusting it until it behaved in the same way that the real industry behaved under similar circumstances. On finding the model to be stable for a fixed input—product demand—the study group subjected it to five types of demand variation, super-imposed on a static demand of 90,000 square yards per week. These were: a step input, ramp growth (steadily growing demand), pulse input (simulating first-of-the-week backlog), cyclic input (representing seasonal variations), and random "noise" (representing small normal fluctuations). The model reacted to each demand variation by compensating for the change and then seeking to return to the static level—it demonstrated behavior like that of the industry it simulated.

OPERATION OF MODEL

The operation of a concern in any sector of the industry is greatly influenced by its inventory adjustment policy. Too slow a response to changed demand could result in some items being overstocked and others out of stock, while too rapid a response would result in a more stable inventory at greater production cost. In the model each sector was started with an inventory sufficient for 2 weeks of normal operation and replenished by orders requiring 2 weeks for delivery. The inventory levels of the model showed some fluctuation and then stabilized at the starting level, much as do the originals of the model.

Stability of levels of inventory, unfilled orders, machine-hours of mill operation, and production in the model were measured to evaluate the response to changes in desired inventory level and the effects of variations in policy. Seven different policies were tested; stability was obtained with use of the 2-week practice and, with special treatment for reordered carpeting and unfilled orders, a 1-week policy. The other policies tested were found to be patently unsatisfactory.

Also of interest to the industry are findings concerning the dependence of the inventory level

on variety of items stocked. Specifically, how much would the inventory for each item have to be increased to enable filling the same percentage of orders if the number of items offered is reduced? Or, with increased variety how much can the inventory per item be reduced? The qualitative relationship is already well understood by industry; models can add quantitative information.

Analysis of operation of the tufted carpet industry model suggests areas for further study; these include expansion of manufacturing capacity, consumer-industry interaction, and merchandising and credit. Future study of the mill-wholesaler-retailer relationship, particularly in regard to ordering, inventories, and transportation, should be useful to the industry. Most important, executives and administrators should see in the simulation model a tool that could be useful for other industries also.